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Project selection for oil-fields development by using the AHP and fuzzy TOPSIS methods

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ABSTRACT

The evaluation and selection of projects before investment decision is customarily done using, technical and information. In this paper, proposed a new methodology to provide a simple approach to assess alternative projects and help the decision-maker to select the best one for National Iranian Oil Company by using six criteria of comparing investment alternatives as criteria in an AHP and fuzzy TOPSIS techniques. The AHP is used to analyze the structure of the project selection problem and to determine weights of the criteria, and fuzzy TOPSIS method is used to obtain final ranking. This application is conducted to illustrate the utilization of the model for the project selection problems. Additionally, in the application, it is shown that calculation of the criteria weights is important in fuzzy TOPSIS method and they could change the ranking. The decision-maker can use these different weight combinations in the decision-making process according to priority.

1. Introduction

Every project begins with a proposal, but not every proposal can or should become a project. In a world of limited resources, choices have to be made. Not every project has viability and amongst those that do, limited resources (people, time, money and equipment), must be applied judiciously. The goal of the project selection process is to analyze project viability and to approve or reject project proposals based on established criteria, following a set of structured steps and checkpoints. Mehrez and Sinuany-Stern (1983) formulated a project selection problem as a multi-criteria decision-making (MCDM) problem and applied a utility function. Chu, Hsu, and Fehling (1996) used a heuristic method based on the fuzzy logic for ranking projects. The problem for the optimal project funding implies decisions on the new projects and on the projects to be continued. The decision on how to allocate the financial resources between these two types of projects is very important issue studied by Baker and Freeland (1975). Danila (1999) and Shpak and Zaporojan (1996) surveyed a number of the project selection methodologies and discussed several multi-criteria aspects of the problem. Khorramshahgole and Steiner (1998) used goal programming associated to a Delphi process for finding the utility map. Lockeett and Straford (1987) presented several 0–1 mathematical programming models which take into account the hierarchical decisions and the fund allocation problem between independent projects. A different approach is based on the reference point and reference level by Lewandowski and Grauer (1995) and Wierzbicki (1980) the reference level is represented by a set of performance measures, which are associated to each attribute. The basic idea of the method is to find the nearest feasible non-dominated solution from the point defined by reference levels. Ghasemzadeh, Archer, and Iyogun (1999) proposed a 0–1 integer linear programming model for selecting and scheduling an optimal project portfolio, based on the organization's objectives and constraints. For a proper and effective evaluation, the decision-maker may need a large amount of data to be analyzed and many factors to be considered (Ayag & Ozdemir, 2006; Kuma, Ordóñez, & Nasseriana, 2006).

This approach is employed for four reasons:

(1) TOPSIS logic is rational and understandable.
(2) The computation processes are straightforward.
(3) The concept permits the pursuit of best alternatives for each criterion depicted in a simple mathematical form.
(4) The importance weights are incorporated into the comparison procedures (Wang & Chang, 2007).

This paper showed that AHP is used to analyze the structure of the project selection problem and to determine weights of the criteria, and fuzzy TOPSIS method is used to obtain final ranking.

2. Methods

2.1. The AHP method

AHP, developed by Saaty (1980), addresses how to determine the relative importance of a set of activities in a multi-criteria

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decision problem. The process makes it possible to incorporate judgments on intangible qualitative criteria alongside tangible quantitative criteria (Badri, 2001). The AHP method is based on three principles: first, structure of the model; second, comparative judgment of the alternatives and the criteria; third, synthesis of the priorities. In the literature, AHP, has been widely used in solving many complicated decision-making problems (Chan & Kumar, 2007; Dagdeviren & Yüksel, 2008; Kahraman, Ruan, & Dogan, 2003; Kulak & Kahraman, 2005). In the first step, a complex decision problem is structured as a hierarchy. AHP initially breaks down a complex multi-criteria decision-making problem into a hierarchy of interrelated decision criteria, decision alternatives. With the AHP, the objectives, criteria and alternatives are arranged in a hierarchical structure similar to a family tree. A hierarchy has at least three levels: overall goal of the problem at the top, multiple criteria that define alternatives in the middle, and decision alternatives at the bottom (Albayrak & Erensal, 2004). The second step is the comparison of the alternatives and the criteria. Once the problem has been decomposed and the hierarchy is constructed, prioritization procedure starts in order to determine the relative importance of the criteria within each level. The pairwise judgment starts from the second level and finishes in the lowest level, alternatives. In each level, the criteria are compared pairwise according to their levels of influence and based on the specified criteria in the higher level (Albayrak & Erensal, 2004). In AHP, multiple pairwise comparisons are based on a standardized comparison scale of nine levels (Table 1).

Let $C = \{C_j \mid j = 1, 2,\ldots, n\}$ be the set of criteria. The result of the pairwise comparison on n criteria can be summarized in an (n_n) evaluation matrix A in which every element a_{ij} $(i,j = 1,2,\ldots, n)$ is the quotient of weights of the criteria, as shown:

$$A = \begin{bmatrix} a_{11} & \ldots & a_{12} & \ldots & a_{1n} \\ \vdots & & \vdots & & \\ a_{21} & \ldots & a_{22} & \ldots & a_{2n} \\ \vdots & & \vdots & & \\ a_{n1} & \ldots & a_{n2} & \ldots & a_{nn} \end{bmatrix} \qquad a_{ii=1},\ a_{ji} = 1/a_{ij},\ a_{ij} \neq 0. \tag{1}$$

At the last step, the mathematical process commences to normalize and find the relative weights for each matrix. The relative weights are given by the right eigenvector (w) corresponding to the largest Eigen value $(\lambda_{\max})$ as:

$$A_w = \lambda_{\max} w. \tag{2}$$

If the pairwise comparisons are completely consistent, the matrix A has rank 1 and $\lambda_{\max} = n$. In this case; weights can be obtained by normalizing any of the rows or columns of A Wang and Yang, 2007. It should be noted that the quality of the output of the AHP is strictly related to the consistency of the pairwise comparison judgments. The consistency is defined by the relation between the entries of $A : a_{ij} \times a_{jk} = a_{ik}$. The consistency index CI is:

$$\mathrm{CI} = (\lambda_{\max} - n)/(n - 1). \tag{3}$$

Table 1
Nine-point intensity important scale.

Definition	Intensely of importance
Equally important	1
Moderately more important	3
Strongly more important	5
Very strong more important	7
Extremely more important	9
Intermediate more important	2, 4, 6, 8

The final consistency ratio (CR), usage of which let someone to conclude whether the evaluations are sufficiently consistent, is calculated as the ratio of the CI and the random index (RI), as indicated.

$$\mathrm{CR} = \mathrm{CI}/\mathrm{RI}. \tag{4}$$

The number 0.1 is the accepted upper limit for CR. If the final consistency ratio exceeds this value, the evaluation procedure has to be repeated to improve consistency. The measurement of consistency can be used to evaluate the consistency of decision-makers as well as the consistency of overall hierarchy (Wang & Yang, 2007).

2.2. The fuzzy TOPSIS method

The TOPSIS is widely used for tackling ranking problems in real situations. This method is often criticized for its inability to adequately handle the inherent uncertainty and imprecision associated with the mapping of the decision-maker's perception to crisp values. In the traditional formulation of the TOPSIS, personal judgments are represented with crisp values. However, in many practical cases the human preference model is uncertain and decision-makers might be reluctant or unable to assign crisp values to the comparison judgments (Chan & Kumar, 2007; Shyur & Shih, 2006). Having to use crisp values is one of the problematic points in the crisp evaluation process. One reason is that decision-makers usually feel more confident to give interval judgments rather than expressing their judgments in the form of single numeric values. As some criteria are difficult to measure by crisp values, they are usually neglected during the evaluation. Another reason is mathematical models that are based on crisp value. These methods cannot deal with decision-makers' ambiguities, uncertainties and vagueness which cannot be handled by crisp values. The use of fuzzy set theory (Zadeh, 1965) allows the decision-makers to incorporate unquantifiable information, incomplete information; non-obtainable information and partially ignorant facts into decision model (Kulak, Durmusoglu, & Kahraman, 2005). As a result, fuzzy TOPSIS and its extensions are developed to solve ranking and justification problems (Büyükzkan, Feyzioglu, & Nebol, 2008; Chen & Tsao, 2007; Kahraman, Büyükzkan, & Ates, 2007; Onüt & Soner, 2007; Wang & Elhag, 2006; Yong, 2006). This study uses triangular fuzzy number for fuzzy TOPSIS. The reason for using a triangular fuzzy number is that it is intuitively easy for the decision-makers to use and calculate. In addition, modeling using triangular fuzzy numbers has proven to be an effective way for formulating decision problems where the information available is subjective and imprecise (Chang, Chung, & Wang, 2007; Chang & Yeh, 2002; Kahraman, Beskese, & Ruan, 2004; Zimmerman, 1996). In practical applications, the triangular form of the membership function is used most often for representing fuzzy numbers (Xu & Chen, 2007). In the following, some basic important definitions of fuzzy sets are given (Raj & Kumar, 1999).

Definition 1. A fuzzy set $\tilde{A}$ in a universe of discourse X is characterized by a membership function $\mu_{\tilde{a}}$ which associates with each element x in X a real number in the interval [0, 1]. The function value $\mu_{\tilde{A}}$ is termed the grade of membership of x in $\tilde{A}$.

Definition 2. A triangular fuzzy number $\tilde{a}$ can be defined by a trip let (a_1, a_2, a_3) shown in Fig. 1. The membership function $\mu_{\tilde{a}}$ is defined (Amiri, Amiri, & Amiri, 2009).

$$\mu_{\tilde{a}}(x) = \begin{cases} 0 & x < a_1 \\ \frac{x-a_1}{a_2-a_1} & a_1 < x < a_2 \\ \frac{x-a_3}{a_2-a_3} & a_2 < x < a_3 \\ 0 & x < a_3 \end{cases} \tag{5}$$

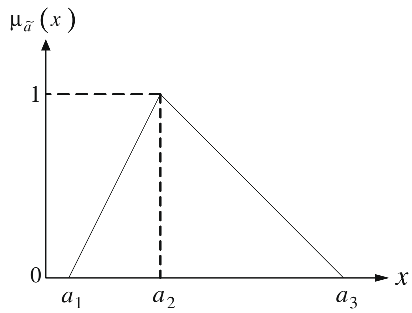

Fig. 1. A triangular fuzzy number $\tilde{a}$.

Let $\tilde{a}$ and $\tilde{b}$ be two triangular fuzzy numbers parameterized by the triplet (a_1, a_2, a_3) and (b_1, b_2, b_3), respectively, then the operational laws of these two triangular fuzzy numbers are as follows:

$$\tilde{a}(+)\tilde{b} = (a_1, a_2, a_3)(+)(b_1, b_2, b_3) = (a_1 + b_1, a_2 + b_2, a_3 + b_3) \quad (6)$$

$$\tilde{a}(-)\tilde{b} = (a_1, a_2, a_3)(-)(b_1, b_2, b_3) = (a_1 - b_1, a_2 - b_2, a_3 - b_3) \quad (7)$$

$$\tilde{a}(\times)\tilde{b} = (a_1, a_2, a_3)(\times)(b_1, b_2, b_3) = (a_1 \times b_1, a_2 \times b_2, a_3 \times b_3) \quad (8)$$

$$\tilde{a}(/)\tilde{b} = (a_1, a_2, a_3)(/)(b_1, b_2, b_3) = (a_1/b_3, a_2/b_2, a_3/b_1) \quad (9)$$

$$\tilde{a} = (ka_1, ka_2, ka_3) \quad (10)$$

Definition 3. A linguistic variable is a variable values of which are linguistic terms (Zadeh, 1975). The concept of linguistic variable is very useful in dealing with situations which are too complex or too ill-defined to be reasonably described in conventional quantitative expressions (Zadeh, 1975). For example, "weight" is a linguistic variable; its values are very low, low, medium, high, very high, etc. These linguistic values can also be represented by fuzzy numbers.

Definition 4. Let $\tilde{a} = (a_1, a_2, a_3)$ and $\tilde{b} = (b_1, b_2, b_3)$ be two triangular fuzzy numbers, then the vertex method is defined to calculate the distance between them.

$$d(\tilde{a}, \tilde{b}) = \sqrt{\frac{1}{3}\left[(a_1 - b_1)^2 + (a_2 - b_2)^2 + (a_3 - b_3)^2\right]} \quad (11)$$

Definition 5. Considering the different importance values of each criterion, the weighted normalized fuzzy-decision matrix is constructed as.

$$\tilde{V} = [\tilde{V}_{ij}]_{n \times j}, \quad i = 1, 2, \ldots, n, \quad j = 1, 2, \ldots, J, \quad (12)$$

Where

$$\tilde{V}_{ij} = \tilde{x}_{ij} \times W_i$$

- A set of performance ratings of $A_j = (j = 1, 2, \ldots, j)$ with respect to criteria $C_i = (i = 1, 2, \ldots, n)$ called $\tilde{x} = (\tilde{x}_{ij}, \quad i = 1, 2, \ldots, n, \quad J = 1, 2, \ldots, J)$;
- A set of importance weights of each criterion $W_i = (i = 1, 2, \ldots, n)$.

According to briefly summarized fuzzy theory above, fuzzy TOPSIS steps can be outlined as follows (Onüt & Soner, 2007):

Step 1: Choose the linguistic values ($\tilde{x}_{ij}, \quad i = 1, 2, \ldots, n, \quad J = 1, 2, \ldots, J,$) for alternatives with respect to criteria. The fuzzy linguistic rating ($\tilde{x}_{ij}$) preserves the property that the ranges of nor malized triangular fuzzy numbers belong to [0, 1]; thus, there is no need for normalization.

Step 2: Calculate the weighted normalized fuzzy-decision matrix. The weighted normalized value $\tilde{V}_{ij}$ calculated by Eq. (12).

Step 3: Identify positive-ideal (A^*) and negative-ideal (A^-) solutions. The fuzzy positive-ideal solution (FPIS, A^*)and the fuzzy negative-ideal solution (FNIS, A^-) are shown in the following equations:

$$A^* = \{\tilde{v}_1^*, \tilde{v}_2^*, \ldots \tilde{v}_i^*\} = \{(\max_j v_{ij} | i \in I'), \times(\min_j v_{ij} | i \in I'')\},$$
$$i = 1, 2, \ldots, n, \quad j = 1, 2, \ldots, J \quad (13)$$

$$A^- = \{\tilde{v}_1^-, \tilde{v}_2^-, \ldots \tilde{v}_i^-\} = \{(\min_j v_{ij} | i \in I'), \times(\max_j v_{ij} | i \in I'')\},$$
$$i = 1, 2, \ldots, n, \quad j = 1, 2, \ldots, J \quad (14)$$

where I' is associated with benefit criteria and I'' is associated with cost criteria.

Step 4: Calculate the distance of each alternative from A^* and A^- using the following equations:

$$D_j^* = \sum_{j=1}^{n} d(\tilde{V}_{ij}, \tilde{V}_i^*) \quad j = 1, 2, \ldots, J. \quad (15)$$

$$D_j^- = \sum_{j=1}^{n} d(\tilde{V}_{ij}, \tilde{V}_i^-) \quad j = 1, 2, \ldots, J. \quad (16)$$

Step 5: Calculate similarities to ideal solution.

$$CC_j = \frac{D_j^-}{D_j^* + D_j^-} \quad j = 1, 2, \ldots J. \quad (17)$$

3. The proposed model

The proposed model for the project selection problem, composed of AHP and fuzzy TOPSIS methods, consists of three basic stages: (1) identify the criteria to be used in the model, (2) AHP computations, (3) evaluation of alternatives with fuzzy TOPSIS and determination of the final rank. In the first stage, alternative projects and the criteria which will be used in their evaluation are determined and the decision hierarchy is formed. AHP model is structured such that the objective is in the first level, criteria are in the second level and alternative projects are on the third level. In the last step of the first stage, the decision hierarchy is approved by decision-making team. After the approval of decision

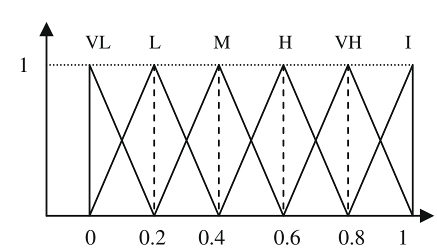

Fig. 2. Linguistic values for criteria rating.

Table 2
Linguistic values and fuzzy number.

Linguistic variables	Fuzzy numbers
Very low (VL)	(0, 0, 0.2)
Low (L)	(0, 0.2, 0.4)
Medium (M)	(0.2, 0.4, 0.6)
High (H)	(0.4, 0.6, 0.8)
Very high (VH)	(0.6, 0.8, 1)
Excellent (E)	(0.8, 1, 1)

hierarchy, criteria used in selection projects are assigned weights using AHP in the second stage. In this phase, pairwise comparison matrixes are formed to determine the criteria weights. The experts from decision-making team make individual evaluations using the scale provided in Table 1, to determine the values of the elements of pairwise comparison matrixes. Computing the geometric mean of the values obtained from individual evaluations, a final pairwise comparison matrix on which there is a consensus is found. The weights of the criteria are calculated based on this final comparison matrix. In the last step of this phase, calculated weights of the criteria are approved by decision-making team. Project ranks are determined by using fuzzy TOPSIS method in the third stage. Linguistic values are used for evaluation of alternative projects in this step. The membership functions of these linguistic values are shown at (Fig. 2), and the triangular fuzzy numbers related with these variables are shown in (Table 2). The selection project having the maximum CC_j^* value is determined as the optimal project according to the calculations by fuzzy TOPSIS. Ranking of the other project is determined according to CC_j^* in descending order schematic. The criteria to be used in the model were determined by the expert team from project managers in National Iranian Oil Company. The application performed is based on the steps pro-

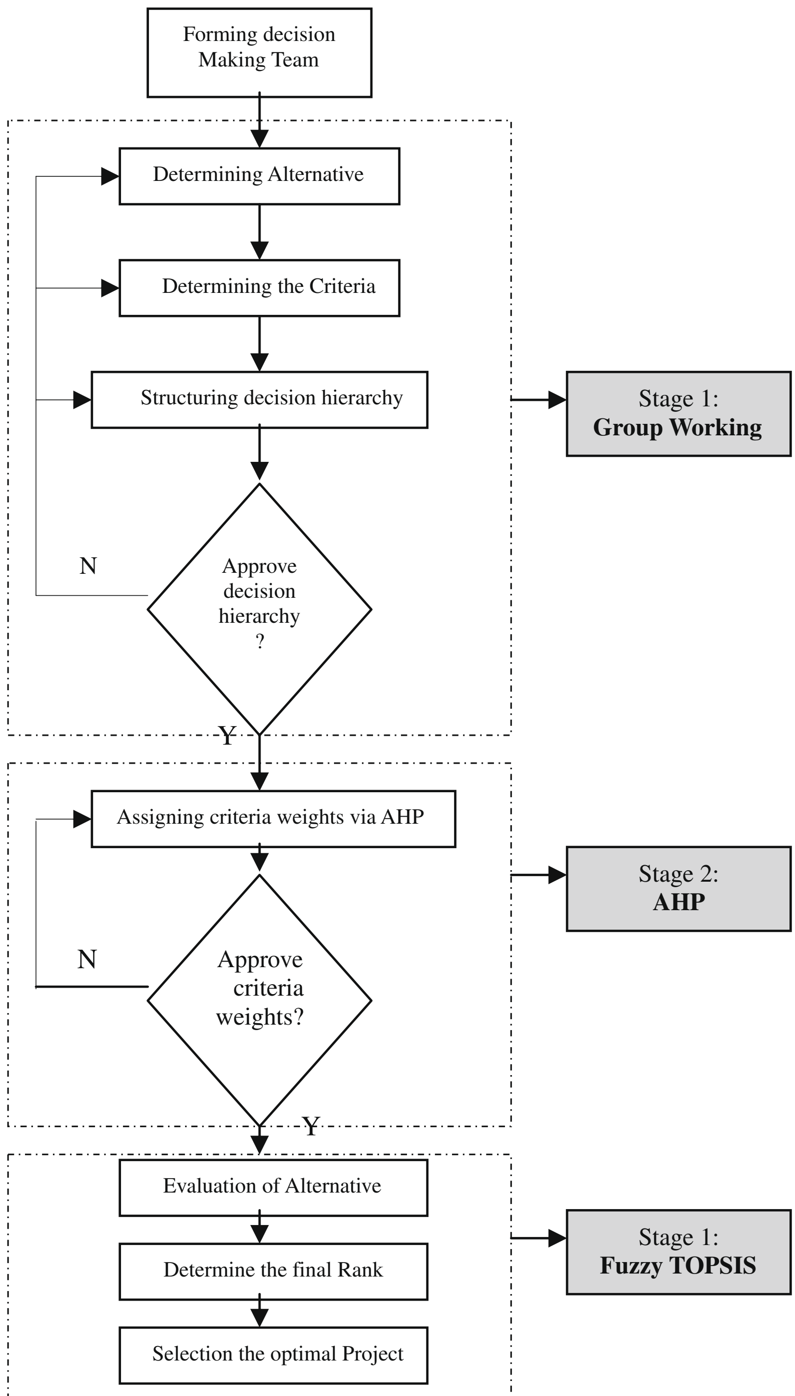

Fig. 3. Schematic diagram of the proposed model for selection.

Table 3
Criteria and alternatives project selection.

Criteria's	Criterion	Definition
C1	Size/complexity	Does size/complexity change the performance of players and timeliness of decisions?
C2	Reasonableness of cost estimates	Reasonableness of cost estimates or reasonableness of terms in contract
C3	Scope–adequacy, level of detail	Adequacy, level of detail
C4	Duration	Were there many personnel changes on either side during the project?
C5	Technology	Was the technology proven/evaluated prior to the project start? If not, how was the technology proven during the project?
C6	Location	Did location play a role in project success?
Alternatives	No. of projects	Project areas (oil-field)
A1	Extension of phase 2	Azadegan
A2	Extension of phase 3	Khesht
A3	Extension of phase 5	Hengam
A4	Extension of phase 8	Yadavaran
A5	Extension of phase 10	Darkhoein

vided in Section 2 and explained step by step together with the results. Pairwise comparison matrices used to calculate criteria weights were also formed by the same team. Diagram of the proposed model for project selection is provided in Fig. 3.

3.1. Identification of criteria

Criteria to be considered in the selection of projects are determined by the expert team from National Iranian Oil Company. These six criteria are as follows; size/complexity (C1), reasonableness of cost estimates (C2), scope–adequacy, level of detail (C3), duration (C4), technology (C5), location (C6). As a result, only these six criteria were used in evaluation and decision hierarchy is established accordingly (Table 3).

3.2. The weights of criteria

After forming the decision hierarchy for the problem, the weights of the criteria to be used in evaluation process are calculated by using AHP method. In this phase, the experts in the expert team are given the task of forming individual pairwise comparison matrix by using the scale given in Table 1. Decision hierarchy structured with the determined alternative projects and criteria is provided in Fig. 4. Geometric means of these values are found to obtain the pairwise comparison matrix on which there is a consensus (Table 4).

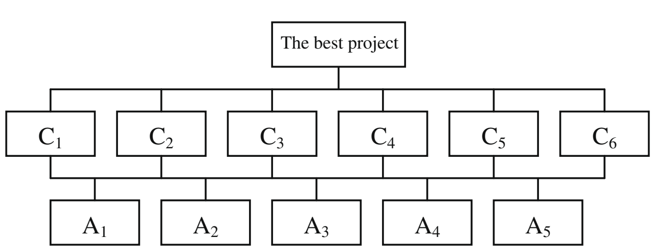

Fig. 4. The decision hierarchy of project selection.

Table 4
Matrix for criteria (pairwise comparison).

	C1	C2	C3	C4	C5	C6
C1	1.0	0.3	0.4	0.4	0.3	0.4
C2	2.2	1.0	3.2	1.9	2.6	2.1
C3	2.2	0.2	1.0	0.4	0.4	0.3
C4	3.1	0.5	3.3	1.0	2.6	1.7
C5	2.3	0.3	2.1	0.4	1.0	1.8
C6	1.7	0.3	2.3	0.5	0.4	1.0

Table 5
Results obtained with AHP.

Criteria	W	$\lambda_{\max}$	CI	RI	CR
C1	0.071	6.338	0.068	1.18	0.058
C2	0.301				
C3	0.083				
C4	0.258				
C5	0.146				
C6	0.133				

The results obtained from the computations based on the pairwise comparison matrix provided in Table 4, are presented in Table 5.

Consistency ratio of the pairwise comparison matrix is calculated as $0.058 < 0.1$. So the weights are shown to be consistent and they are used in the selection process.

3.3. Evaluation of alternatives and determine the final rank

At this stage, fuzzy evaluation matrix established by the evaluation of alternatives by linguistic variables in Table 2, is presented in Table 6. Linguistic variables are in the upper section of Table 6, the lower section is composed of the triangular fuzzy numbers which are equivalent of linguistic variables. After the fuzzy evaluation matrix was determined, the second step is to obtain a fuzzy weighted decision table. Using the criteria weights calculated by AHP (Table 5) in this step, the Weighted Evaluation Matrix (WEM) is established with Eq. (12). According to Table 7, it is seen that the element $\tilde{V}_{ij}, \quad \forall_i$ j are normalized positive triangular fuzzy numbers and their ranges belong to the closed interval [0, 1]. Thus, defined the fuzzy positive-ideal solution (FPIS, A^*) and the fuzzy negative-ideal solution (FPIS, A^-) as $\tilde{V}_i^* = (1,\ 1,\ 1)$ and $\tilde{V}_i^- = (0,\ 0,\ 0)$ for benefit criterion, and $\tilde{V}_i^* = (0,\ 0,\ 0)$ and $\tilde{V}_i^- = (1,\ 1,\ 1)$ for cost criterion. In this problem, for the third step, the distance of each alternative from D^* and D^- can be currently calculated using Eqs. (15) and (16). The fourth step solves the similarities to an ideal solution by Eq. (17) (Yang & Hung, 2007). Illustrate steps 3 and 4 for CC1:

$$
\begin{aligned}
D_1^- = {} & \sqrt{\frac{1}{3}[(1-0)^2 + (1-0.028)^2 + (1-0.043)^2]} \\
& + \sqrt{\frac{1}{3}[(1-0.181)^2 + (1-0.241)^2 + (1-0.301)^2]} \\
& + \sqrt{\frac{1}{3}[(0-0.066)^2 + (0-0.083)^2 + (0-0.083)^2]} \\
& + \sqrt{\frac{1}{3}[(0-0.103)^2 + (0-0.155)^2 + (0-0.206)^2]} \\
& + \sqrt{\frac{1}{3}[(0-0.0029)^2 + (0-0.058)^2 + (0-0.088)^2]} \\
& + \sqrt{\frac{1}{3}[(0-0.053)^2 + (0-0.081)^2 + (0-0.106)^2]} \\
= {} & 2.121
\end{aligned}
$$

Table 6
Fuzzy evaluation matrix for the alternative project.

	C1	C2	C3	C4	C5	C6
A1	(0, 0.4, 0.6)	(0.6, 0.8, 1)	(0.8, 1, 1)	(0.4, 0.6, 0.8)	(0.2, 0.4, 0.6)	(0.4, 0.6, 0.8)
A2	(0.6, 0.8, 1)	(0, 0.2, 0.4)	(0.2, 0.4, 0.6)	(0.8, 1, 1)	(0.4, 0.6, 0.8)	(0.2, 0.4, 0.6)
A3	(0.4, 0.6, 0.8)	(0.6, 0.8, 1)	(0.8, 1, 1)	(0.4, 0.6, 0.8)	(0.6, 0.8, 1)	(0.6, 0.8, 1)
A4	(0, 0.4, 0.6)	(0.4, 0.6, 0.8)	(0.4, 0.6, 0.8)	(0.6, 0.8, 1)	(0.6, 0.8, 1)	(0.4, 0.6, 0.8)
A5	(0, 0.2, 0.4)	(0.4, 0.6, 0.8)	(0.6, 0.8, 1)	(0.2, 0.4, 0.6)	(0, 0.2, 0.4)	(0.2, 0.4, 0.6)
W	0.071	0.301	0.0083	0.258	0.146	0.133

Table 7
Weighted evaluation for alternatives.

Alternatives	C1	C2	C3	C4	C5	C6
A1	(0.000, 0.028, 0.043)	(0.181, 0.241, 0.301)	(0.066, 0.083, 0.083)	(0.103, 0.155, 0.206)	(0.029, 0.058, 0.088)	(0.053, 0.081, 0.106)
A2	(0.043, 0.057, 0.00)	(0.00, 0.060, 0.120)	(0.017, 0.034, 0.050)	(0.206, 0.258, 0.258)	(0.58, 0.088, 0.118)	(0.027, 0.053, 0.080)
A3	(0.028, 0.043, 0.043)	(0.181, 0.241, 0.301)	(0.066, 0.083, 0.083)	(0.103, 0.155, 0.206)	(0.088, 0.117, 0.146)	(0.080, 0.105, 0.132)
A4	(0.00, 0.028, 0.043)	(0.120, 0.181, 0.241)	(0.034, 0.050, 0.067)	(0.155, 0.206, 0.258)	(0.088, 0.117, 0.146)	(0.053, 0.080, 0.106)
A5	(0.00, 0.014, 0.028)	(0.120, 0.181, 0.241)	(0.050, 0.067, 0.083)	(0.052, 0.103, 0.155)	(0.00, 0.029, 0.058)	(0.027, 0.053, 0.080)

Table 8
Results.

Alternatives	D_j^*	D_j^-	CC_j	Rank
A1	3.906	2.121	0.351	A2
A2	3.704	2.334	0.386	A4
A3	3.830	2.189	0.363	A3
A4	3.765	2.261	0.375	A1
A5	3.955	2.081	0.344	A5

$$
\begin{aligned}
D_1^* &= \sqrt{\frac{1}{3}[(1-0)^2+(1-0.028)^2+(1-0.043)^2]} \\
&+ \sqrt{\frac{1}{3}[(1-0.181)^2+(1-0.241)^2+(1-0.301)^2]} \\
&+ \sqrt{\frac{1}{3}[(0-0.066)^2+(0-0.083)^2+(0-0.083)^2]} \\
&+ \sqrt{\frac{1}{3}[(0-0.103)^2+(0-0.155)^2+(0-0.206)^2]} \\
&+ \sqrt{\frac{1}{3}[(0-0.0029)^2+(0-0.058)^2+(0-0.088)^2]} \\
&+ \sqrt{\frac{1}{3}[(0-0.053)^2+(0-0.081)^2+(0-0.106)^2]} \\
&= 3.906
\end{aligned}
$$

$$
CC_j = \frac{D_j^-}{D_j^* + D_j^-} = \frac{2.121}{3.906 + 2.121} = 0.351
$$

Finally, with using Table 8, the value of each alternative for final ranking will be:

Therefore, the final ranking is:

$A2 > A4 > A3 > A1 > A5.$

4. Conclusion

The project selections process is a technique for evaluating the basic suitable investment and to choose the best candidate by using a multi-criteria approach that using linguistic preferences can be very useful for uncertain situations. The AHP is used to analyze the structure of the project selection problem and to determine weights of the criteria, and fuzzy TOPSIS method is used to obtain final ranking. Similar calculations are done for the other alternatives and the results of fuzzy TOPSIS analyses are summarized in Table 8. Based on CC_j values, the ranking of the alternatives in descending order are A2, A4, A3, A1 and A5. Proposed model results indicate that A2 is the best alternative with CC value of 0.386 (extension phases 3 – Khesht oil-field). In the application, it is shown that calculation of the criteria weights is important in fuzzy TOPSIS method and they could change the ranking for other project.

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